INTERFACE FOCUS

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The biomedical applications of graphene

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This issue of *Interface Focus* is a collection of papers on 'The biomedical applications of graphene'. The idea to put together this theme issue evolved during discussions between Prof. Peter N.T. Wells CBE, FREng, FMedSci, FRS and myself in mid-2016. Very sadly, about a year ago, Prof. Wells passed away. However, before that and even in the various last stages of his life he was intensely involved in planning this theme issue with me. I am deeply indebted to him for his contributions towards this and I dedicate this theme issue to him as a memorial.

Introduction

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One contribution of 13 to a theme issue 'The biomedical applications of graphene'.

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1. Introduction

The very important role of graphene and graphene derivatives in science and engineering is indisputable, but their significance in biomedicine is less clear at the present time. In this theme issue, we aim to discuss this dilemma, illustrating areas of promise while identifying future challenges. In order to do this, we have invited papers from authors from various disciplines and geographical locations. Consequently, this issue is rich in the science, technology and engineering of graphene in biomedicine, covering both the life and physical sciences, engineering and medicine. Our authors come from the UK, the USA, Europe, Australia and Asia and cover a wide variety of topics.

The first paper by Banerjee [1] reviews the current status very effectively. He first discusses the unique properties of graphene and its derivatives and follows this up with a wide-ranging discussion on recent progress in the applications of graphene and its derivatives in several different areas of biomedicine. Subsequently, the challenges involved in the use of these advanced materials in biomedical applications are elucidated, and the future perspectives for their use are discussed. The review provides an outlook on the new possibilities to inspire broader interests across various biomedicine disciplines.

There is quite a lot of global discussion on whether graphene is a versatile nano-platform for biomedical applications. Linklater *et al*. [2] in their paper illustrate the processes involved in bactericidal mechanisms, which are not well established at present. This is followed by a paper by Bugli *et al*. [3], who illustrate that curcumin-loaded graphene derivatives can provide the nano-morphology in fighting methicillin-resistant bacteria. Graphene oxide is one of the most used and leading graphene derivatives and, in their paper, Verre *et al*. [4] vividly demonstrate the effects of graphene oxide substrates in increasing gene expression of biomolecules. The nano-platform is taken further by Yang *et al*. [5], who are developing carbon (diamond)-coated nano-porous membranes for cellular attachment.

Graphene quantum dots (GQDs) usually constitute a single to tens of layers of graphene and are of a size less than a few tens of nanometres. Owing to their exceptional properties, in particular biocompatibility, GQDs are considered to be a novel material for biological applications. Their bioavailability in lung tissues is demonstrated by Tabish *et al*. [6], and Justin & Chen [7] illustrate how nano-composites containing GQDs can be used in drug delivery.

Biosensors are key assets when attempting the early diagnosis and monitoring of disease. The recent advances in graphene-based materials for making very sensitive and selective biosensor devices are vividly described by Szunerits & Boukherroub [8]. Point-of-care devices for sensing diseases is very topical

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and the use of the aquaporin–graphene interface with respect to renal cell carcinoma is illustrated in the paper by Jakowiecki *et al*. [9].

The creation of novel science in relation to biomedicine and graphene is of immense importance, but the translation of these exciting developments into actual manufacturing is also crucial in order to facilitate application. The paper by De Sanctis *et al*. [10] attempts just that. These authors illustrate how novel routes of manufacturing, especially with respect to patterning by functionalizing graphene-based materials with different chemical entities, can be effective. In their paper, Matharu *et al*. [11] show how graphene can be incorporated in polymers to manufacture fibres using a novel gyratory technique, and elucidate how these are effective as anti-bacterial deposits. Kazantseva *et al*. [12] take the topic of graphene-based fibres even further by showing how networks of composite graphene–ceramic fibres can be used in the control of stem cells.

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Competing interests. I declare I have no competing interests.

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